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Assessment of Regional Transport with Map Deformation: A Case Study for Budapest

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Abstract

Transport systems exist in geographic space and the time-space. This implies the travel time. Nowadays the time is getting more and more important. This article not only shows the method for time-space visualization but as a tool for analyse regional transport systems in Budapest Hungary. The method initially developed in the 1960s but due to the low computational capacity at that time not evolved yet. The current widely available computational capacity made it possible to make such assessments for smaller areas. However, these methods have not been pursued beyond this initial flurry of research activity, most likely due to the difficulties associated with handling and processing huge amount of digital geographic data and the difficulties of the developed software environment. This paper describe not only the method but the preliminary results of assessment of regional transport system in Budapest.

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Keywords: assessmen; regional transport; map deformation.

1. Introduction

Distorted maps are commonly build in order to highlight relevant information. Distorted maps can be used to reveal the bottlenecks with distortion of travel time to assess regional transport. Understanding the travel time relationships induced by a transport system can be crucial for increasing its performance. Greater time efficiency for movement can enhance individuals' accessibilities to activities and resources by freeing more time for travel and activity participation

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(Hägerstrand 1970). Spatial variations and patterns in these travel time relationships can help transport analysts and planners understand relative differences in system performance, guiding the planning, design and deployment of transport infrastructure and services towards efficient and equitable outcomes. The travel time relationships induced by a transport system imply a time-space connection where relative locations and proximity relationships can differ from those in geographic space. As with geographic space, mapping and spatial analysis of time-spaces can be illuminating. Time-space maps can provide a synoptic visual summary of the travel time relationships in a given environment, indicating areas where the transport system is performing well and other areas where it is inefficient. Also, since induced travel time relations are central to transport systems, spatial analysis of time-space can be more meaningful than analysis of geographic space in understanding transport system performance (Nobbir, Harvey 2007). Several attempts were done even in Hungary for travel time based maps (Fig. 1).

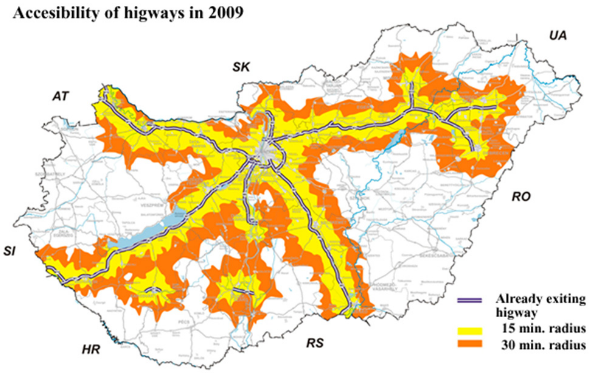

Fig. 1. Accessibility of highways (source: KTI – Institute for Transport Sciences).

The aim of authors was to build up a distorted map that significantly shows the changes in travel time compared to geographical map but not only for one mode of transport as such models are already existing, (Ficzere, Ultmann, Török 2011) but to extend the model to assess all modes. Authors have investigated the different kind of transformations of regional transport maps in order to gain new information on possible developments (e.g. rate of centralisation, missing links, etc.). The basic Budapest agglomeration has been examined but the described method can be adapted to other areas as well. Nowadays railway reaches its second "golden-age", at European level more and more funds are available for railway investments even in suburban areas in order to increase efficient usage of railroad (Gašparík, Zitrický 2010). A method had been investigated which is able not only to analyse the reduction of travel time in the agglomeration as a social benefit for the current system but is capable of estimating the social benefits of future investments and modifications as well. In this paper author has investigated the agglomeration of Budapest (Fig. 2).

Total area of investigation 6 393.14 km^2, population according to 2011 census is 1 217 476 inhabitant in the area. Population average density is 190 inhabitants/km^2. There are coach, and train service in the area. Beyond them passenger car transport (both on national road and on expressway) was also incorporated to analysis.

2. Methodology

Mapping time-spaces has a long history in spatial analysis. Research dates back to pioneering work in the 1960s by Waldo Tobler and William Bunge (Bunge 1960; Tobler 1961). Cartographic transformations to generate time–spaces reached a peak in the 1970s with the work of researchers such as Marchand (1973), Forer (1974, 1978), Ewing, Wolfe (1977), Clark (1977), Muller (1978). Despite the efforts of these and subsequent researchers, key issues surrounding time-space mapping remain unresolved. Inconclusive results regarding the nature of time-spaces and their structure probably result from the state of key transformation techniques such as multidimensional scaling (MDS) and map comparison techniques. There are different ways to establish the connection between the two, different type of maps (the travel time and the geographical map) such as in case of Berta and Torok (2010). The easiest and most accurate way was to find some control points (significant points, which can be easily find on both of the two maps) to determine the mathematical relationship. In our case 14 different points were given in the transformations (Budapest and nearby settlements to Budapest). The corresponding travel time data were collected between them for coach for train and for passenger car and two different origin destination matrices were built in Excel spreadsheet for each mode. One is based on geographical distance and the other is for travel time. The model is very similar to Torok model (Ficzere, Ultmann, Torok 2014) but extended to other relevant transport modes of the agglomeration.

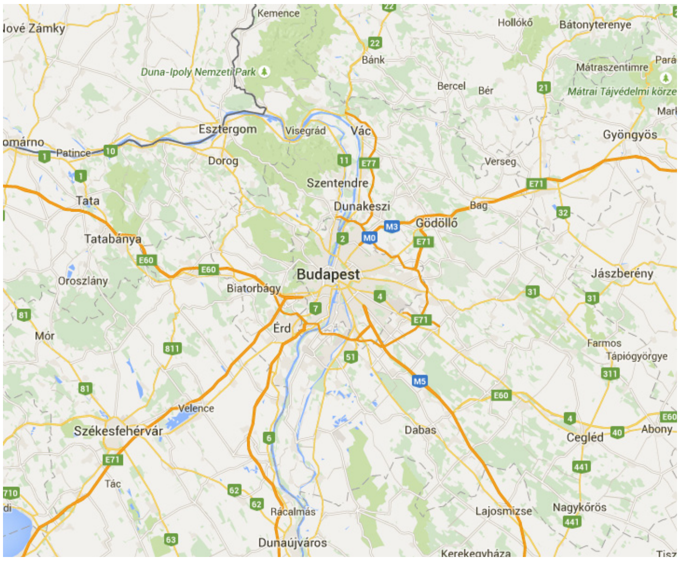

Fig. 2. Geographical situation of agglomeration of Budapest.

Author has investigated the possible map transformation and found that rubber sheet method (Doytsher 2000) provides the best fitting solution. It is based on a “flexible surface” in which the original map points are not uniformly transformed. The “rubber sheet” transformations can be implemented partly as well – they are usually called patch – so the map can be divided into regions and every part can have of its own transformation equation. The equations need to satisfy the continuity condition of parts, namely the first and second derivates supposed to be the same in the connecting points. Therefore the residuals are always zero. The main equation cannot be described in a closed form, it vary locally.

3. Results

The transformation matrices (origin and destination matrices for all transport modes for geographical distances measured on travel path and for travel time also) were used to modify the geographical map in order to investigate the transport situation in the agglomeration of Budapest. The input dataset were based on the average travel time from schedule.

As it can be seen on Fig. 3 the red line shows the average travel time for passenger cars from Budaörs is more than 1 hour. The yellow line shows the average travel time for passenger cars from Budaörs is more than 1/2 hour. The yellow line shows the average travel time for passenger cars from Budaörs is less than 1/4 hour. These lines give very little information therefore map distortion were use (Fig. 4).

The same maps (geographical and distorted) were calculated for coach and train services as well. The model has extended and not only the modal solutions were created but the overall minimal travel time were also visualized. The overall minimum were calculated based on the separated modes and their travel time were minimalized.

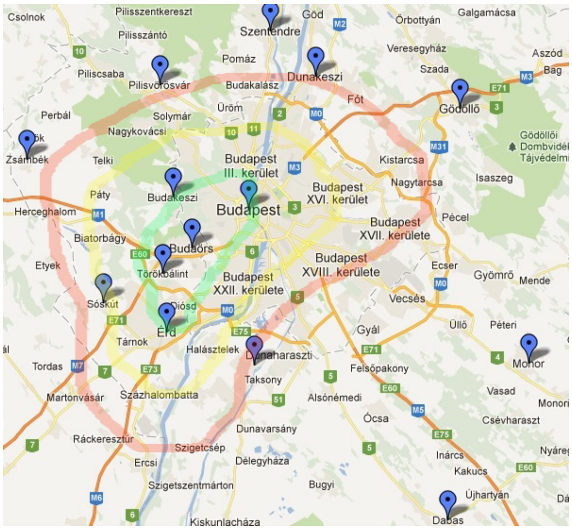

Fig. 3. Geographical map of agglomeration – isochrone curves of passenger car transport.

Fig. 4. Distorted map of agglomeration – isochrone curves (circles) of passenger car transport.

4. Analysis

As it can be seen form Fig. 5 and Fig. 6 the agglomeration of Budapest transport links were examined based on the travel time. Public (coach and train service) and private car (on motorway and on national road) transport were also considered and combined analysis were done. Having analysed the current status and development potential of the Hungarian expressway and railroad networks in the agglomeration it can be stated that the individual road vehicle use in the agglomeration is economically more beneficial, the public transport can be competitive, but the service level must be increased in order to increase attractiveness. This is especially valid for the south-west part of the agglomeration of Budapest, where settlements are located near to other, such as Budaörs, Budakeszi, Törökbálint, Sóskút and Érd. It can be stated that the transport connection in north-west and south-east direction needs to be improved. As it can be seen on the map (Fig. 5 or Fig. 6) the travel time in these directions are higher.

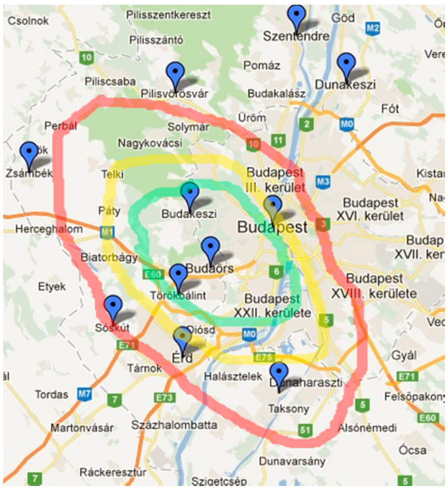

Fig. 5. Geographical map of agglomeration – minimal isochrone curves of transport in the agglomeration.

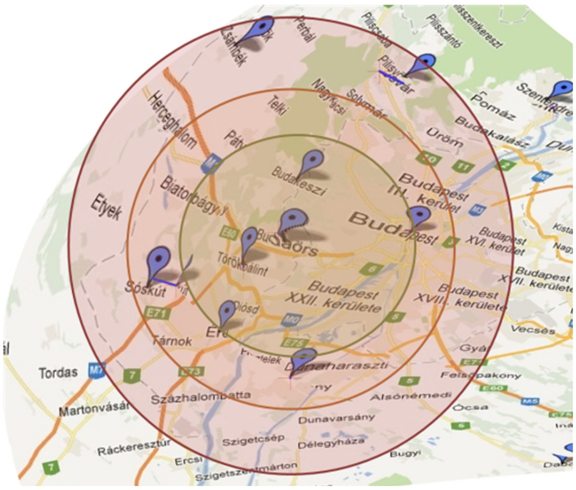

Fig. 6. Distorted map of agglomeration – isochrone curves (circles) of transport in agglomeration.

The presented system is suitable for analysis of transport time related infrastructure development or changes, particularly with regard to social benefits from the shortening of travel time.

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